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Spatial Autocorrelation Analysis of Stunting Prevalence in Central Java Province

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Abstract

Stunting remains high in Central Java, with a prevalence of 20.8% in 2022, posing a serious threat to the realization of Indonesia's Golden Generation 2045 due to its direct impact on future human resource quality. This study aims to examine the spatial autocorrelation of stunting prevalence in Central Java Province in 2023. An quantitative descriptive study was conducted using aggregated data from 35 districts/cities. Secondary data were sourced from the 2023 Central Java Health Profile and the Central Bureau of Statistics. Data analysis employed Moran's Index and Local Indicators of Spatial Association (LISA) using GeoDa software. This study shows that each stunting determinant has a distinct spatial pattern in Central Java Province. The variables of adequate sanitation, chronic energy deficiency (CED), and exclusive breastfeeding exhibit significant spatial patterns, whereas iron supplementation (TTD 90), low birth weight (LBW), and access to clean drinking water display random distributions. Adequate sanitation forms a significant cluster in Wonogiri, CED is concentrated in Tegal, Pemalang, Purbalingga, and Banyumas, while high exclusive breastfeeding coverage is found in Purworejo and low coverage in Salatiga. Integrated interventions that incorporate spatial factors and local determinants are essential to effectively and equitably reduce stunting prevalence across Central Java.

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Introduction

Stunting, characterized by a child's height below -2 standard deviations according to the WHO growth curve, remains a serious public health issue in Indonesia. Although its prevalence has decreased nationally, recent data indicate that the rate of stunting remains high, affecting approximately 21.6% of children under five years old. This condition has long-term consequences not only for physical growth but also for cognitive development, increases the risk of chronic diseases, reduces productivity, and contributes to national economic losses of around 3.99% of the Gross Domestic Product (GDP). The persistently high prevalence of stunting also poses a major barrier to achieving the Golden Generation 2045, a productive, healthy, and competitive generation expected to dominate Indonesia's demographic structure by the centennial of independence.

The geographical distribution of stunting is uneven, tending to form specific spatial patterns or clusters. Several international studies have reported high Global Moran's I values, indicating positive spatial autocorrelation in the prevalence of malnutrition. For instance, a multi-country study by Aheto et al. (2022) reported Moran's I values ranging from 0.72 to 0.78 across 73 developing countries; in India, the Moran's I was 0.31 ($p = 0.000001$), while in Ethiopia, spatial hotspots were observed with a Moran's I value of 0.40 ($p < 0.001$). At the national level, Sipahutar et al. (2024) identified positive spatial autocorrelation in stunting prevalence across 514 districts/cities in Indonesia, with more than 130 regions classified as stunting hotspots. Local research, such as that conducted in West Bandung Regency, also confirms the importance of area-based approaches in stunting reduction interventions.

Stunting is a national program, and three out of the ten regions prioritized under the national stunting program are located in Central Java.(Anjani et al., 2022) Central Java Province is a priority region with a high stunting burden and diverse geographical as well as socioeconomic characteristics across its districts and cities. Therefore, detailed spatial analysis at the district/city level is crucial to identify interregional connectivity patterns and detect clusters with high (hotspots) or low (coldspots) stunting prevalence. The findings from such analyses can serve as a scientific basis for developing place-based interventions aimed at accelerating stunting reduction in alignment with the Indonesia Emas 2045 national target outlined in the National Medium-Term Development Plan (RPJMN).

Although national-level studies have identified positive spatial autocorrelation and clustering of stunting across Indonesian districts and cities, there remains a lack of in-depth understanding regarding the spatial clustering patterns and the variability of stunting determinants specifically within Central Java Province. The geographical and socioeconomic heterogeneity at the district/city level necessitates more detailed localized analysis, as spatial patterns and determinant effects at the provincial scale have not yet been fully explored. This study aims to address this research gap by conducting spatial autocorrelation analysis using the Moran's Index and Local Indicators of Spatial Association (LISA) on stunting prevalence and its key determinants in Central Java. The results are expected to identify specific hotspots and coldspots, and to provide targeted, effective, and equitable intervention recommendations that are better suited to the local context compared to broader national approaches that may overlook local spatial diversity.

Methods

This study employed a quantitative descriptive design with spatial analysis to identify the spatial distribution pattern of stunting prevalence and related factors in Provinsi Jawa Tengah, Indonesia. The unit of analysis was the district/municipality level, selected based on the availability and consistency of aggregated secondary data from Central Bureau of Statistics and 2023 Central Java Health Profile. Although analysis at the sub-district or village level could provide finer spatial resolution, such data were not consistently available across the province.

The variables analyzed included stunting prevalence, sanitation (percentage of households with access to improved sanitation), chronic energy deficiency (pregnant women with MUAC < 23.5 cm), low birth weight (infants < 2,500 g), iron–folic acid tablet coverage (≥ 90 tablets during pregnancy), exclusive breastfeeding (0–6 months), and access to clean drinking water. Data were obtained from the Central Java Provincial Health Profile and official publications from BPS and the Ministry of Health.

To test whether the prevalence of stunting shows a non-random spatial distribution pattern, Global Moran's I analysis was used. Moran's I values > 0 indicate positive spatial autocorrelation (high areas tend to be surrounded by high areas, and vice versa), while values < 0 indicate negative autocorrelation. Values approaching 0 indicate a random distribution.(Anselin, 1995)

LISA Analysis (Local Indicators of Spatial Association) used to identify local clusters in the form of hotspot (High-High), coldspot (Low-Low), with outlier (High-Low and Low-High). This helps determine priority areas for intervention. Visualization was performed using Moran's Scatterplot and LISA cluster maps. Significance testing was performed at the 95% confidence level ($\alpha = 0.05$). The significance of Moran's I and LISA values was determined through Monte Carlo simulation with 999 permutations.(Getis & Ord, 1992) All of these spatial analyses used the GeoDa program, which allows for the calculation of the Moran's I index, Monte Carlo simulations of 999 permutations, and interactive spatial visualizations that support a more comprehensive interpretation of the results.

Results

The results of the global autocorrelation test on the six variables using GeoDa *software* at the Figure 1. obtained Moran's I values for all variables including CED (0.185), provision of TTD 90 (0.006), LBW (0.088), provision of Exclusive Breastfeeding (0.199), Sanitation (-0.250), and Clean drinking water (0.003). The Moran's I value for the CED variable, provision of TTD 90, LBW, provision of Exclusive Breastfeeding and Clean drinking water index is greater than E[I] which means there is a positive spatial autocorrelation in the five variables and shows a (*clustered*) distribution pattern, having similarities between locations. While the Sanitation variable index is smaller than E[I] which means there is a negative autocorrelation. This shows that the distribution pattern is spread out (*random*), has no similarities between locations.

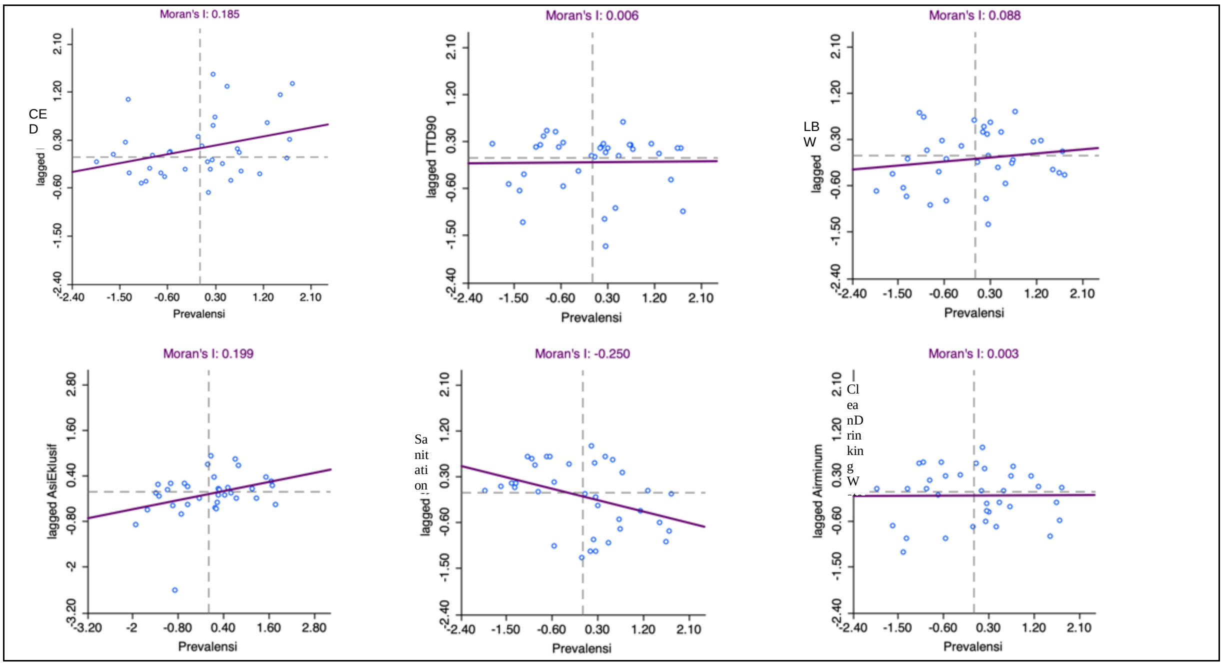

Figure 1. *Moran's I Scatterplot* Variable

Bivariate analysis using Moran's I and LISA values was determined through Monte Carlo simulation with 999 permutations to observe the spatial autocorrelation between the variables CED, provision of 90 iron tablets, low birth weight, exclusive breastfeeding, sanitation, and clean drinking water with the prevalence of stunting. The results of the analysis can be seen in Table 1.

Table 1. Bivariat Moran's I Analysis Stunting Prevalence

Variable	Moran's I	E[I]	Z value
Chronic Energy Deficiency (CED)	0.1847	-0.0294	2.0247
90 Iron Tablets	0.0059	-0.0294	0.0574
Low Birth Weight (LBW)	0.0877	-0.0294	1.0566
Exclusive Breastfeeding	0.1991	-0.0294	2.2620
Sanitation	-0.2499	-0.0294	-2.7562
Clean Drinking Water	0.0033	-0.0294	-0.0229

Global Moran's I analysis was used to test for spatial autocorrelation in stunting determinant variables at the district/city level in Central Java Province. A positive Moran's I value indicates spatial clustering (areas with high values tend to be adjacent to other high-value areas, and vice versa), while a negative value indicates different distribution patterns between regions (high areas are surrounded by low areas, and vice versa). The CED variable has a Moran's I value of 0.1847 with an expected value of E[I] of -0.0294 and a *z-score* of 2.0247. This value indicates positive spatial autocorrelation, meaning areas with a high CED prevalence tend to be adjacent to other areas that also have a high prevalence. Similarly, the Exclusive Breastfeeding variable shows a higher Moran's I value of 0.1991 with a *z-score* of 2.2620, indicating a fairly strong positive spatial pattern. Both variables indicate the presence of clusters of regions with similar characteristics.

The Proper Sanitation variable shows a negative Moran's I value, namely -0.2499 with a *z-score* of -2.7562. This indicates the presence of negative spatial autocorrelation, which means that areas with high sanitation access tend to be adjacent to areas with low access, indicating a scattered or non-uniform distribution pattern. The LBW variable has a Moran's I value of 0.0877 and a *z-score* of 1.0566, indicating weak positive spatial autocorrelation. Meanwhile, the provision of 90 iron tablets and Access to Clean Drinking Water variables each have very low Moran's I values (0.0059 and 0.0033) and *z-scores* close to zero (0.0574 and 0.0229), indicating that the distribution pattern of both variables tends to be random or does not show clear spatial autocorrelation.

Overall, this analysis indicates that the CED and Exclusive Breastfeeding variables exhibit positive spatial clustering, while sanitation tends to be scattered or separated across regions. Other variables have not shown consistent spatial patterns. These results provide a basis for further local spatial analysis using LISA to identify priority area clusters for stunting reduction in Central Java.

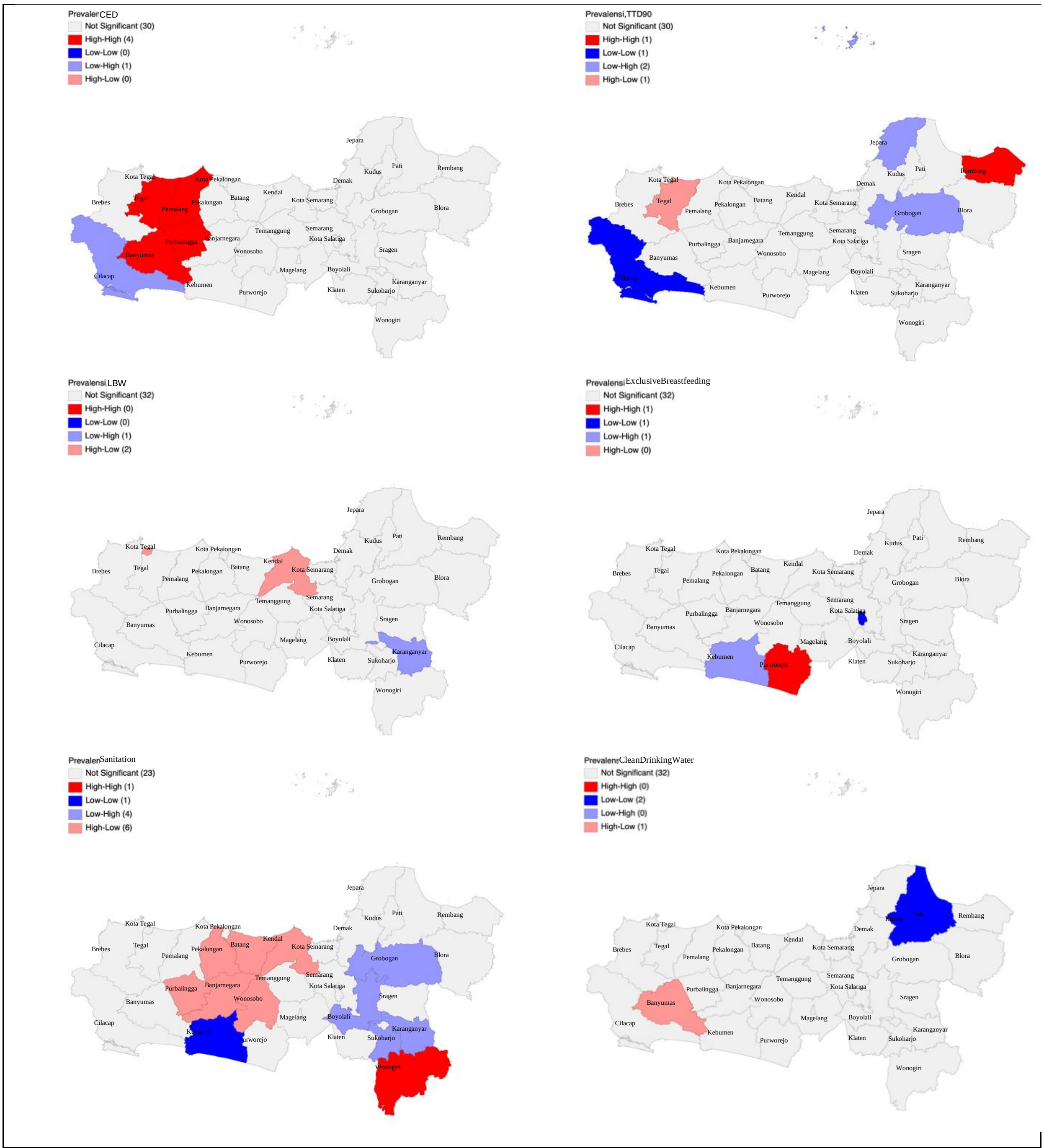

Figure 2. *LISA Cluster Map* Stunting Prevalence

The results of local spatial analysis using LISA (Local Indicators of Spatial Association) indicate the presence of significant clusters in several determinant variables of stunting in Central Java Province. For the CED variable, a *High-High* cluster was identified in the western and southwestern regions of the province, indicating a concentration of areas with a high CED prevalence in close proximity to each other. These areas include Tegal Regency, Pemalang Regency, Purbalingga Regency, and Banyumas Regency. On the other hand, there is a *Low-High* cluster in the northwest and south, indicating areas with a low CED prevalence that are also adjacent to an area with a high CED prevalence, namely Cilacap Regency. This pattern indicates that the CED has a fairly structured spatial distribution.

The variable of giving TTD 90, shows the existence of a *High-High* cluster in the northeast region, namely Rembang Regency, which reflects the concentration of high coverage of iron supplement consumption by pregnant women. Conversely, the western region, namely Cilacap Regency, shows a *Low-Low* pattern indicating low TTD coverage spatially. Several regions also show outliers in the form of *High-Low*, namely Tegal Regency and *Low-High*, namely Jepara Regency and Grobogan Regency, which indicates inhomogeneity of values between neighboring regions. A similar thing also occurs in the LBW variable, where the spatial pattern is dominated by outliers, with a few regions showing a *High-Low* tendency, namely Tegal City and Kendal Regency, while the region with a *Low-High* tendency is Karanganyar Regency, without the formation of a large significant cluster.

In the Exclusive Breastfeeding variable, a *High-High* cluster is clearly visible in the southern region, namely Purworejo Regency, indicating areas with high exclusive breastfeeding coverage that are close together. Conversely, the eastern region forms a *Low-Low* cluster, indicating a concentration of areas with low exclusive breastfeeding coverage, namely Salatiga City. This variable indicates a strong spatial trend. On the other hand, there is one *Low-High* cluster in the northwest and south, indicating areas with low CED prevalence that are also close to areas with high CED prevalence, namely Kebumen Regency.

Based on the results of the LISA spatial analysis of stunting prevalence associated with access to sanitation and clean drinking water, it was found that sanitation shows a stronger spatial pattern than drinking water. On the sanitation map, Wonogiri Regency is included in the *High-High* cluster, meaning it has a high stunting prevalence and is surrounded by areas with a high prevalence as well. This condition indicates the presence of a significant risk cluster and requires priority intervention. Several areas such as Banjarnegara Regency, Kendal Regency, Pekalongan Regency, Wonosobo Regency, Batang Regency, and Purbalingga Regency are in the *High-Low* cluster, namely areas with a high stunting prevalence but surrounded by areas with a low prevalence, indicating a positive outlier. Meanwhile, areas such as Grobogan Regency, Boyolali Regency, Sukoharjo Regency, and Karanganyar Regency are in the *Low-High* cluster, namely areas with a low stunting prevalence but located in high-risk environments, thus potentially affected if no prevention measures are taken. Kebumen Regency is the only area in the *Low-Low* cluster, indicating a relatively safe spatial condition against stunting related to sanitation.

On the other hand, the analysis of the drinking water variable shows that most regions lack significant spatial patterns, with only two regions, Kudus Regency and Pati Regency, falling into the *Low-Low* cluster, and one region, Banyumas Regency, falling into the *High-Low* cluster. This finding suggests that sanitation has a more significant spatial relationship to stunting than access to drinking water, and therefore, interventions to improve sanitation quality are more appropriately focused on regions with these significant clusters.

Overall, the LISA results reinforce the finding that several variables, such as CED, TTD 90, and Exclusive Breastfeeding, have significant spatial clustering patterns, making them important for planning area-based interventions. Meanwhile, other variables exhibit spatial irregularities and require a more contextual and cross-regional policy approach.

Discussion

The results of the spatial analysis of the CED variable show a clustered distribution pattern, structured spatially. The Moran's I value is 0.1847 with an expected value E[I] = -0.0294 and a z-score of 2.0247, indicating significant positive spatial autocorrelation. This means that areas with high CED prevalence tend to be close to other areas with similarly high prevalence, and vice versa. These results are reinforced by LISA analysis which shows a *High–High* cluster in the western and southwestern regions, namely Tegal Regency, Pemalang Regency, Purbalingga Regency, and Banyumas Regency. These four regions constitute a geographic concentration of high CED and are *hotspot* that need to be prioritized in nutrition policy interventions.

In addition, Cilacap Regency is identified as a *Low-High* cluster, which means it is an area with low prevalence of CED but is directly in line to areas with high malnutrition prevalence. Such areas are referred to as buffer zone, which are areas that have not been directly impacted but are at risk of being affected due to their spatial closeness to hotspots. Intervention strategies that only focus on areas with high prevalence are often ineffective without considering these buffer zones, as spatial effects (*spill-over*) can cause CED conditions to spread to surrounding areas through overlapping economic, social, or healthcare connections.

The concept of buffer zones becomes important in spatial intervention planning because these areas can be starting points for the expansion of problems if not addressed preventively. This approach is consistent with various international studies that reveal the importance of spatial autocorrelation in understanding the distribution of nutritional issues. For instance, Khan and Mohanty (2018) found a Moran's I value of 0.65 in the distribution of child stunting in India and used bivariate LISA to show the spatial correlation between malnutrition.(Khan & Mohanty, 2018a) Research by Zhang et al. (2018) in China also applied Moran's I in the context of metabolic diseases and found that regions with similar conditions tend to cluster geographically, supporting a spatial approach in public health policy.(Zhang et al., 2019) This is same line with previous research which states that the spatial distribution of malnourished children in India is greatly influenced by regional factors, it emphasizes the need for spatially-based nutritional interventions that consider clusters and buffer zones simultaneously.(Shaw et al., 2020)

Spatial analysis of the variable of providing at least 90 iron tablet supplements during pregnancy shows a distribution pattern that tends to be random, indicated by a very low Moran's I value (0.0059) and a z-score of 0.0574, thus not showing any significant global spatial autocorrelation. However, the results of the LISA analysis successfully identified noteworthy local clusters. A *High-High* cluster was found in the Rembang District, indicating a high concentration of TTD consumption coverage by pregnant mothers in that area and its surroundings. Conversely, Cilacap District showed a *Low-Low* cluster, indicating a low coverage of TTD that is geographically close to each other. This illustrates systemic challenges in the distribution and monitoring of supplementation in areas with limited access to healthcare services, as also shown in previous studies.(Titaley & Dibley, 2013)

In addition, there are also spatial outliers, such as *High–Low* in Tegal Regency, and *Low–High* in Jepara Regency and Grobogan Regency, which indicate heterogeneity among neighboring regions. This suggests that although the overall pattern of distribution is random, there are areas with extreme conditions compared to their neighbors that can be prioritized for intervention. Tegal Regency as a *High-Low* cluster reflects local success amidst areas with low coverage, indicating the presence of effective practices that can be replicated in surrounding regions. A similar study by Gebreamlak et al. (2017) in Ethiopia showed that education and family support significantly influence compliance with TTD consumption.(Gebreamlak et al., 2017)

On the other hand, Jepara and Grobogan Regencies fall into the *Low-High* cluster, indicating areas with low iron supplementation coverage despite being surrounded by areas with high coverage. This indicates gaps in program implementation, such as poor quality outreach or suboptimal monitoring by health workers. In this context, Sartika et al. (2024) in a cohort study showed that administering ≥180 iron supplementation tablets during pregnancy can reduce the risk of anemia by up to 75% (aRR 0.25), reinforcing the importance of full coverage in maternal nutrition intervention programs.(Sartika et al., 2024)

Global analysis of LBW showed a Moran's I value of 0.0877 and a z-score of 1.0566, indicating a weak positive spatial autocorrelation but not forming a broad cluster, but rather dominated by outlier patterns. This pattern is seen in the *High-Low* in Tegal and Kendal City, as well as the *Low-High* in Karanganyar, reflecting the local and heterogeneous distribution of LBW. Research by Annisa Nur Falah et al. (2025) using the Expanded Spatial Durbin Model for stunting in Java, found that malnutrition and HDI display spatial autocorrelation, but the distribution of indicators is influenced by local exogenous variables.(Falah et al., 2025) Previous research supports these findings. A study by Saragih et al. (2020) stated that the distribution of LBW in Indonesia is spatially discontinuous, with many cases scattered as outliers without forming large clusters.(Banerjee et al., 2020a) In addition, a study by Muflikhah et al. (2018) in Java found that the incidence of LBW was higher in areas with low access to antenatal care (ANC) and poor maternal nutritional status, and this pattern appeared locally in the form of small clusters or outlier.(Donal et al., 2018) Studies in developing countries such as Kenya have also reported similar results, where LBW patterns do not form broad clusters, but show small regional variations that require attention from locally based health programs.(Banerjee et al., 2020b) The main factors correlated with high rates of LBW include inadequate maternal nutrition during pregnancy, insufficient iron supplementation (IBT), maternal age being too young or too old, and low frequency of antenatal care visits. A global meta-analysis emphasized that iron deficiency, anemia, and chronic energy deficiency in pregnant women are closely associated with the incidence of LBW.(Boateng et al., 2024)

The results of the spatial analysis of the Exclusive Breastfeeding variable indicate a non-random distribution pattern, but rather a tendency towards positive spatial autocorrelation. This is evident from the Moran's I value of 0.1991 and the z-score of 2.2620, indicating that areas with high exclusive breastfeeding coverage tend to be adjacent to other areas with high coverage. This finding is reinforced by the LISA analysis which identified a *High-High* cluster in the southern region, specifically in Purworejo Regency, as an area with a high concentration of exclusive breastfeeding coverage. Meanwhile, Salatiga City emerged as a *Low-Low* cluster, indicating areas with low exclusive breastfeeding coverage that are adjacent to each other. Between these two extreme patterns, there is a *Low-High* cluster in Kebumen Regency, which reflects a buffer zone, namely an area with low coverage that directly borders a high-performing area, thus having the potential to be impacted if not handled preventively.

This spatial pattern is in line with previous studies which stated that using Global Moran's I to identify the spatial distribution of exclusive breastfeeding practices in Ethiopia, and found the presence of significant clusters that require area-based interventions.(Sako et al., 2024) This finding is supported by Tebeje et al. (2024), who, using a Multiscale Geographically Weighted Regression (MGWR) approach, showed that local determinants significantly influence spatial variation in breastfeeding practices in Ethiopia.(Tebeje et al., 2024) Meanwhile, Hailegebreal et al. (2022) in another study found a significant Moran's I value in the distribution of delayed breastfeeding initiation and underlined the importance of a spatial approach in child health planning.(Hailegebreal et al., 2022) In addition, Yaya et al. (2017) also highlighted spatial disparities in exclusive breastfeeding coverage in Sub-Saharan Africa, emphasizing that national strategies that do not consider geographical aspects tend to be less effective.(Yaya et al., 2017) *High-High* areas, such as Purworejo Regency, need to be protected and used as a reference for the best interventions, while *Low-Low* areas, such as Salatiga Regency, need to be the primary target for increased coverage. Meanwhile, *Low-High* areas, such as Kebumen Regency, require a preventive approach and strengthened lactation support. A targeted spatial approach will increase intervention effectiveness, ensure resource efficiency, and support equitable service delivery and the achievement of the national exclusive breastfeeding target.

Spatial analysis of access to adequate sanitation as a determinant variable for stunting in Central Java Province yielded a Moran's I value of -0.2499 and a z-score of -2.7562, indicating negative spatial autocorrelation, meaning that areas with high sanitation access tend to be adjacent to areas with low sanitation access, indicating a dispersed and non-uniform distribution. Although globally it does not form a broad cluster, the LISA map shows a *High-High* cluster in Wonogiri Regency, indicating a high prevalence of stunting adjacent to areas with low sanitation access this is in line with the results of a study by Widya et al. (2024) which found a significant effect of sanitation on stunting in Java.(Widya et al., 2024) On the other hand, several regions such as Banjarnegara, Kendal, Pekalongan, Wonosobo, Batang, and Purbalingga are included in the *High-Low* cluster, namely high stunting prevalence in low sanitation areas surrounded by good sanitation areas this outlier phenomenon is similar to the pattern described by Eryando et al. (2022) in a national study of 514 districts/cities.(Eryando et al., 2022) *Low-High* clusters in areas such as Grobogan, Boyolali, Sukoharjo, and Karanganyar show low prevalence amidst low sanitation access, which reinforces the finding that some Indonesian districts experience random or outlier patterns without forming significant hot/cold spots.(Minawati et al., 2024) This finding is also supported by previous research on the spatial heterogeneity of stunting, where sanitation variables showed strong negative spatial correlations with other health indicators.(Khan & Mohanty, 2018b) Community-based intervention research (CLTS) shows that improving sanitation is key to reducing stunting, and its distribution is random due to uneven geographical implementation of interventions. Furthermore, a study in Nusa Tenggara by Picauly et al. (2023) showed the impact of sanitation on stunting reduction locally, not nationally, similar to the negative Moran's I pattern found in this study.(Picauly et al., 2023) Overall, these results confirm that sanitation interventions in Central Java should be micro-targeted, focusing on villages/sub-districts, especially in the *High-High* and *High-Low* areas, rather than a broad provincial approach, in order to create a more uniform sanitation distribution pattern and have a real impact on stunting reduction.

The analysis of the clean drinking water access variable showed a Moran's I value of 0.0033 and a z-score of –0.0229, indicating a random distribution pattern or no significant spatial autocorrelation. This means that areas with access to improved drinking water do not have a strong spatial relationship with surrounding areas a finding that suggests that drinking water access is not a dominant factor in the spatial pattern of stunting in Central Java Province. Only a few areas were identified as forming clusters, namely Kudus Regency and Pati Regency as the *Low-Low* cluster, and Banyumas Regency as the *High-Low* cluster, which tended to be spatial outliers rather than large clusters. This finding aligns with various previous studies showing that although access to clean drinking water is important, its spatial influence on stunting is not as strong as sanitation factors. A study by Widya et al. (2024) showed that in Java, the spatial correlation between stunting and sanitation was much more significant than that between access to drinking water.(Widya et al., 2024) Furthermore, a study in Ethiopia by Aragie & Asfaw (2020) confirmed that the spatial distribution of clean drinking water does not always reflect the prevalence of stunting, as other factors such as environmental sanitation and maternal education level are more dominant. A study in West Sumatra by Purba et al. (2020) found that clean water quality does not significantly impact stunting if it is not accompanied by adequate basic sanitation facilities.(Purba et al., 2020) Irawati & Hermawati (2023) in DKI Jakarta also emphasized that clean water plays a greater role in diarrheal disease, not directly in stunting, and its influence tends to be non-spatial.(Irawati & Hermawati, 2023) Thus, although access to clean drinking water is an important element in public health, in the spatial context of stunting in Central Java, its influence is less significant than other variables.

Conclusion

This study reveals that each determinant of stunting in Central Java Province has a distinct spatial pattern. Access to adequate sanitation exhibits a significant negative spatial autocorrelation (Moran's I = –0.2499), indicating a scattered but strong spatial distribution, and is the most consistent indicator associated with stunting prevalence. Significant spatial clusters, such as those found in Wonogiri Regency, indicate that adequate sanitation is a dominant spatial factor in stunting prevention. In contrast, the variables for 90-day iron supplementation (Moran's I = 0.0059), low birth weight (Moran's I = 0.0877), and access to clean drinking water (Moran's I = 0.0033) exhibit weak or generally random spatial patterns, although there are several spatial outliers and local clusters, such as in Rembang and Cilacap Regencies, for the 90-day iron supplementation variable.

Meanwhile, CED variable exhibits positive spatial autocorrelation with a Moran's I value of 0.1847 and a z-score of 2.0247, indicating a fairly structured spatial distribution. *High-High* CED clusters were found in Tegal, Pemalang, Purbalingga, and Banyumas Regencies, indicating a concentration of areas with a high CED prevalence in close proximity. This suggests that CED is an important spatial determinant in stunting analysis.

The exclusive breastfeeding variable also showed a positive spatial pattern (Moran's I = 0.1991; z-score 2.2620) with a *High-High* cluster in the southern region, such as Purworejo Regency, and a *Low-Low* cluster in the eastern region, such as Salatiga City, indicating a fairly strong spatial relationship. This indicates that exclusive breastfeeding has an important spatial role that requires attention in stunting intervention strategies.

Author Contributions

S.A Design, Concept, Literature search, Data collection, Data analysis, Preparation of the manuscript, Editing of the manuscript, Review of the manuscript. V.A.V.S Data analysis, Preparation of the manuscript, Editing of the manuscript, Review of the manuscript. F.A Translator, Editing of the manuscript, Review of the manuscript. A.T.W Data collection, Editing of the manuscript, Review of the manuscript. F.W. and M.T.A Review of the manuscript.

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Conflicts of Interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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